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GB 2240219 A EP 0400872 A1 EP 0366393 A2
US 4994820 A

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(54) **Patch antenna having integral probe and methods for constuction thereof**

(57) A microwave patch antenna 100 has a conductive patch 102 and probes 104, 106, formed from a single piece of material. The probes 104, 106 are electrically and mechanically coupled to the patch and are perpendicular to the patch surface. A printed circuit board has a dielectric substrate 110, ground plane 112 and conductive contacts 118. The patch is electrically and mechanically coupled to the contacts 118 by the probes 104, 106. The probes 104, 106 may be feed probes, ground probes and/or tuning probes. A dielectric spacer 108 may be located between the patch and the printed circuit board and the patch may be parallel to the ground plane. Various possibilities are listed with regard to the process for obtaining the patch/probe arrangement, the shape of the patch and the materials to be utilized.

FIG.1

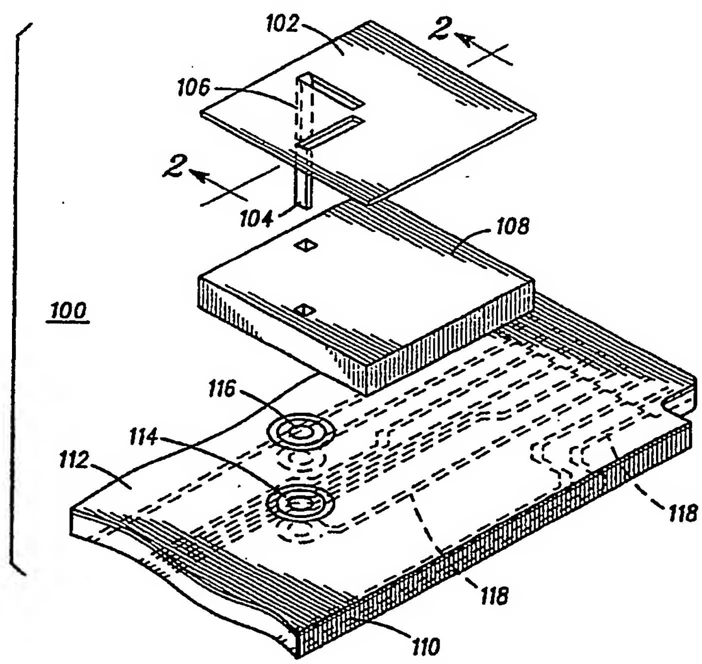

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FIG.1

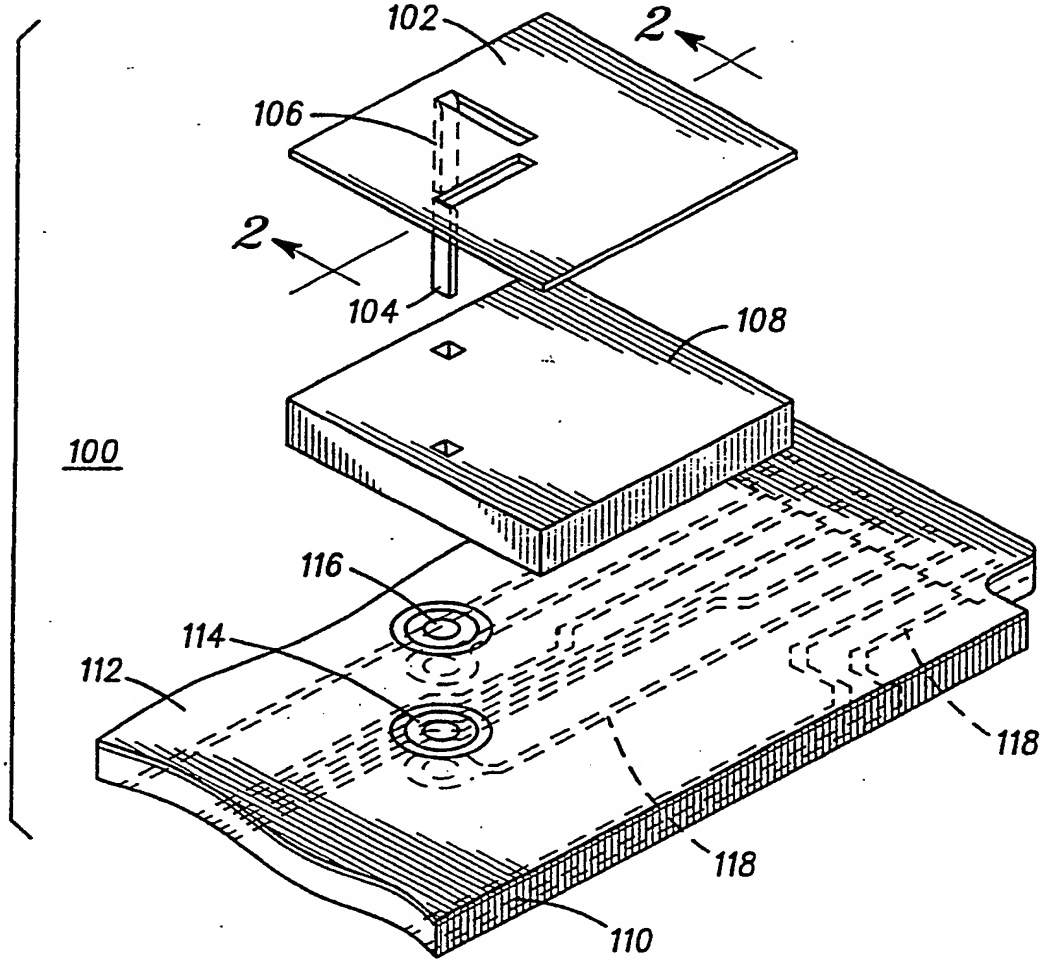
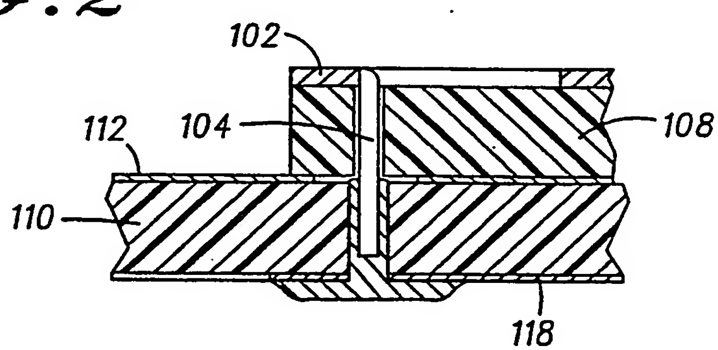

102
2
106
2
104
108
100
116
114
112
118
118
110

FIG.2


102
112
104
108
110
118

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PATCH ANTENNA HAVING INTEGRAL PROBE AND METHODS FOR CONSTRUCTION THEREOF

Technical Field

This invention relates to radio frequency (RF) antennas, and more particularly, to very thin planar microwave antennas that radiate and receive electromagnetic energy over a wide range of frequencies. Specifically, the present invention relates to such an antenna having a mechanical probe configuration and methods for construction thereof.

Background of the Invention

Microwave patch antennas are well known. The use of such antennas has received wide industry acceptance as a consequence of the need for increased miniaturization, decreased cost, improved reliability and ease of manufacture. Such antennas typically comprise a dielectric substrate (i.e., a printed circuit board) with a ground plane on one major surface and strip conductors on the other major surface. The strip conductors provide electrical coupling to a broader conductive area known as a patch via feed probes that are connected to the strip conductors. Said feed probes typically extend through the dielectric substrate for making contact with the patch. The patch may be suspended above the ground plane and supported on a dielectric substrate such that it is parallel to and spaced apart from the ground plane: see FIG. 4 of US Patent No. 4,691,206 Shapter et al.

Unfortunately, the manufacture of patch antennas has in the past been hampered by problems related to overall device height repeatability and reliability. This is especially true when the antenna structure comprises stacked antenna components, wherein mechanical probes connect the patch to the strip conductors of the dielectric substrate. Because the mechanical probes must extend through multiple layers, including the patch, each probe presents an unavoidable obstruction which contributes to the overall antenna height. Overall antenna height, as used herein, is defined as the distance between the patch antenna ground plane and the upper surface of the patch including any and all surface features thereof. Since miniaturization is an emerging industry trend, reduced device height is a desirable goal.

This goal is typically thwarted, however, when physical connections such as, but not limited to: clamps, screws, rivets, welds, adhesive and/or soldering connections are used to secure the probes to the patch during assembly. As will be appreciated, each such physical connection, located at the intersection between the probe and the patch, will extend upward from the surface of the patch to connect to that portion of the probe extending above the patch. As will be appreciated, such physical connections tend to increase the overall device height. In many applications, however, where antenna height is critical to overall device packaging requirements, the presence of such obstructions is intolerable. This is especially true in the field of radio frequency (RF) data communications where small portable hand-held devices are becoming the norm.

It would be extremely advantageous therefore to provide a patch antenna having a physically-robust coupling between the patch and its probes that does not impact device height, improves reliability and ease of manufacture while decreasing overall device cost.

Summary of the Invention

Briefly described, the present invention is a patch antenna adapted to generate or receive microwave frequency electromagnetic radiation and methods for construction thereof. This antenna employs a conductive patch having at least one probe integrated into the conductive patch. A dielectric substrate having a ground plane on one major surface and conductive contacts on another major surface is coupled to the conductive patch via said probe to complete the antenna assembly.

In accordance with the preferred embodiment, the conductive patch and its integral probe are constructed via well known sheet metal fabrication operations. In accordance with yet another embodiment, the conductive patch is constructed via well known metal casting operations. The integral probe may be cast as part of the casting operation or constructed via known sheet metal fabrication operations.

Brief Description of the Drawing

FIG. 1 is an exploded view of a preferred embodiment of a patch antenna in accordance with the present invention; and

FIG. 2 is a partial cross sectional view of the patch antenna shown in FIG. 1.

Detailed Description of a Preferred Embodiment

With reference to the present invention, there is provided a very thin patch antenna that radiates and receives electromagnetic energy. The antenna employs a patch radiator having at least one integral probe that is constructed as an integral part of the patch thereby requiring no additional coupling, mechanical or otherwise, to achieve electrical coupling to the patch. The antenna described herein has application within the field of radio frequency (RF) data communications wherein small portable hand-held devices such as, for example, pagers, RF modems, personal digital assistants (PDAs), personal intelligent communicators (PICs) and the like have critical packaging requirements which benefit from the size and cost savings realized as a result of a reduction in the size and number of components required to comprise such an antenna assembly.

The disclosed antenna is practical for applications at frequencies between approximately 1 and 20 Gigahertz (GHz). While there are no theoretical limits to the range of operating frequencies for use by such antennas, in practice,

patch antennas begin to exhibit high losses when operated above about 20 GHz. At frequencies below 1 GHz, wire antennas become more practical because of the size requirements necessary to implement 1/2 wavelength patch antennas.

Referring now to the drawings, an exploded view of a patch antenna in accordance with the present invention is illustrated in FIG. 1. This patch antenna 100 comprises a conductive material layer 102 hereinafter referred to as a patch. The patch 102 is depicted as having the shape of a parallelogram. In accordance with the preferred embodiment, the patch shape is substantially rectangular and in general will comprise a square. As will be appreciated by those skilled in the art, however, the present invention is in no way limited by the shape of the radiating patch 102. As such it may comprise any polygon, elliptical or circular shape.

The disclosed antenna is designed to operate at approximately 2.4 GHz. In accordance, at least two sides of patch 102 are dimensioned to have lengths equaling 1/2 wavelength of the frequency of operation.

The patch 102 is made of a conductive material such as metal. In accordance with the preferred embodiment, the patch 102 is made of non-corrosive conductive metals, such as, but not limited to copper, nickel, nickel-silver, beryllium-copper, phosphor-bronze or stainless steel.

As depicted in FIG. 1, the patch 102 is further characterized by the presence of integral probes 104 and 106. In accordance with the preferred embodiment, each probe 104 and 106 is substantially rectangular in shape and extends substantially perpendicular to the plane of the patch 102. These

probes may be employed as feed probes or ground probes. Feed probes provide a desired excitation to patch 102. Ground probes are employed to enhance or suppress specific modes of operation within the patch 102 as is known in the art.

In accordance with the preferred embodiment probes 104 and 106 are both feed-type probes. Two feed probes are employed by the depicted embodiment to provide polarization diversity as is known in the art. Since patch antennas employing dual feeds and exhibiting polarization diversity are known, no further discussion on such devices is presented at this time. The interested reader may nonetheless refer to the following references for additional information on the subject. For information on dual probe polarization diversity, refer to M. Haneishi and Y. Suzuki, "Circular Polarization and Bandwidth," Handbook of Microstrip Antennas, Peter Peregrinus Ltd., London 1989, p. 220. For information on optimal probe placement, the interested reader may refer to Mohamed A. Saed, "An Optimization Procedure for a Probe-Fed Rectangular Microstrip Patch Radiator CAD," Microwave Journal, January, 1993, pp. 116-124. Of course, where polarization diversity is not desired, it will be appreciated by those skilled in the art that a single feed probe configuration in accordance with the present invention may be employed.

While the probes 104 and 106 are comprised of substantially rectangular shapes, it will be appreciated by those skilled in the art that additional probe shapes are available and may be used without departing from the spirit of the present invention. Such shapes include, but are not limited to circular probes, conical probes, oval probes or

any other shape that is suitable for a particular application as a feed or ground probe as set forth herein.

As is known in the art, patch 102 may be created via any of the available and well known sheet metal fabrication operations, such as, but not limited to stamping and forming. In addition, patch 102 may be manufactured via any of the well known metal casting processes.

Probes 104 and 106 are created as an integral part of patch 102 by any of the available metal fabrication operations such as, but not limited to, punching, piercing, perforating, shearing or forming. When patch 102 is created via a metal casting process, probes 104 and 106 may comprise integral features of the cast or may be fashioned after the casting operation is completed via any of the above mentioned sheet metal fabrication operations.

In accordance with the preferred embodiment, probes 104 and 106 are punched and formed from the patch 102 to which they are associated. Due to the use of a punch operation, each probe 104 and 106 remains an integral part of the patch 102 to which it is associated. No additional coupling, mechanical or otherwise, is required to provide electrical contact between probes 104 and 106 and the patch 102. No additional piece parts are required to perform the function of a probe. In addition, each probe is comprised of the same identical material as is the patch 102.

Resting under patch 102 is an optional dielectric spacer 108. Such a spacer is known in the art and may be comprised of any of the well known dielectric materials such as, but not limited to dielectric foams, glass-filled epoxy, cyanate ester

polyimide, Teflon or other similar dielectric materials. In accordance with the preferred embodiment, dielectric spacer 108 is made of a layer of Polymethacrylimide foam.

Supporting both the spacer 108 and the patch 102 is a dielectric substrate 110 having a ground plane 112, such as, for example, a printed circuit board (PCB) like those commonly known in the art. Such PCBs may comprise single or multiple layers and typically have a ground plane 112 on one major surface thereof, while another major surface consists of electrical contacts and traces 118 which are electrically isolated from said ground plane 112. In accordance with the present invention, the substrate 110 is adapted to comprise holes 114 and 116 for accepting probes 104 and 106, respectively. The feed probes extend through holes 114 and 116 and make electrical contact with traces 118 in order to complete the antenna assembly.

Of note, since no soldering or other coupling operation is required to connect probes 104 and 106 to patch 102, a reliable and repeatable device height is maintainable without the variances exhibited by prior patch antennas. Moreover, the single-piece unibody construction of patch 102 eliminates the need for separate probes and probe assembly steps as taught by the prior art. In accordance, the patch antenna of the present invention recognizes a significant height reduction and cost savings as compared to prior art patch antennas by integrating the probes into the patch.

Referring to FIG. 2, a partial cross sectional view of the patch antenna 100 of FIG. 1 is shown. FIG. 2 depicts the patch antenna 100 after assembly. As shown, and in accordance with the present

invention, there are no physical obstructions above the surface of the patch 102. While, a coupling procedure, such as, but not limited to soldering, is employed to electrically and mechanically couple patch 102 to electrical contacts 118 of PCB 110 via probes 104,106 these connections do not obstruct, interfere or increase the overall device height as defined herein above.

What is claimed is:

CLAIMS

1. A patch antenna adapted to generate or receive microwave frequency electromagnetic radiation, said antenna comprising:

a conductive patch having a surface characterized by at least one integral probe extending substantially perpendicular therefrom, said probe for providing electrical and mechanical coupling to said patch; and

a dielectric substrate having a ground plane on one major surface thereof and conductive contacts on another major surface thereof, said contacts electrically isolated from said ground plane, said substrate adapted to coupled to the conductive patch via said at least one integral probe to provide said electrical and mechanical coupling.

2. The antenna of claim 1 wherein the frequency of operation is within a range of 1 to 20 GHz.

3. The antenna of claim 1 wherein the conductive patch is coupled to the dielectric substrate and parallel to the ground plane.

4. The antenna of claim 1 further comprising a dielectric spacer resting between the conductive patch and the dielectric substrate, said patch probe extending through the dielectric spacer.

5. The antenna of claim 1 wherein the conductive patch has a shape selected from the group consisting of: parallelograms, polygons, circles and spheres.

6. The antenna of claim 1 wherein at least two sides of the conductive patch have lengths equaling 1/2 wavelength of the frequency of operation.

7. The antenna of claim 1 wherein the conductive patch is made from a metal selected from the group consisting of:

copper, nickel, nickel-silver, beryllium-copper, phosphor-bronze and stainless steel.

8. The antenna of claim 4 wherein the dielectric spacer is made from materials selected from the group consisting of dielectric foams, glass-filled epoxy, cyanate ester, polyimide and Teflon.

9. The antenna of claim 1 wherein the conductive patch is created utilizing a sheet metal operation selected from the group consisting of stamping and forming.

10. The antenna of claim 1 wherein the conductive patch is created utilizing metal casting operations.

11. The antenna of claim 1 wherein the probe is created utilizing a sheet metal operation selected from the group consisting of: punching, piercing, perforating, forming and shearing.

12. The antenna of claim 1 wherein the probe comprises the same material as the conductive patch.

13. The antenna of claim 1 wherein the at least one probe functions as a device, selected from the group consisting of feed probes and ground probes.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report) -13-	Application number GB 9416166.8
Relevant Technical Fields (i) UK Cl (Ed.N) H1Q (QKA) (ii) Int Cl (Ed.6) H01Q (1/38, 9/04)	Search Examiner J A WATT Date of completion of Search 2 NOVEMBER 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ON-LINE DATABASE: WPI	Documents considered relevant following a search in respect of Claims :- 1 TO 13

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2240219 A	(NEC) Figure 2 and lines 14 to 21, page 5	1 at least
X	EP 0400872 A1	(HARADA) Figure 5 and lines 9 to 32, column 7	1 at least
X	EP 0366393 A2	(NOKIA) Figure 2	1 at least
X	US 4994820 A	(NISSAN) Figures 1 to 3C and lines 20 to 68, column 2	1 at least

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